MICHIGAN STATE UNIVERSITY COLLEGE OF ENGINEERING • WINTER 2008/2009

NETWORKS

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Making Waves: Research Explores Uses for Robotic Fish

Robots were once the stuff of science fiction, but now sci-fi and advanced technology meet as robots have many applications in the 21st century. So, what about robotic fish? That's not sci-fi. That's the work of Xiaobo Tan, ECE assistant professor and director of the Smart Microsystems Laboratory.

Tan recently received funding from the Office of Naval Research (ONR) to develop highly maneuverable robotic fish, based on biological principles and incorporating biomimetic electroactive polymers. The current research project builds on the work Tan did with a National Science Foundation (NSF) CAREER project, "Dexterous Biomimetic Micromanipulation Using Artificial Muscles: Modeling, Sensing, and Control." The CAREER project provided a sound knowledge base in electroactive polymers. As part of another NSF grant, Tan's research lab will expand to house a large water tank (about 15 x 10 x 4 feet) to study schools of robotic fish and for a number of outreach activities. The water tank will also be used as part of a project with other MSU researchers to evolve adaptive and cooperative behavior among autonomous systems.

The robotic fish that Tan and his research team have been developing are propelled and maneuvered by soft actuation materials, called electroactive polymers. These materials, also known as artificial muscles, generate large deformations upon application of a voltage. Therefore, these robotic fish have no mechanical noise, unlike other robotic fish that use motors. The robotic fish are currently propelled by a tail fin and contain wireless communication and sensing components. Tan's group is also exploring the use of artificial pectoral fins for maneuvering and assistive propulsion. The latest funding will be used to gain a greater understanding of how fish move and behave in the water. "Real fish have interesting motions in three-dimensional water space, and can navigate through turbulent conditions with ease," says Tan. "We need to understand how this works so our robotic fish can be stable in different flow conditions." For example, Tan wants his robotic fish to be able to handle waves and currents.

The materials used for actuating the robotic fish are as important as the sensors. "We are pursuing fundamental studies on the development of novel

continued on page 2

Inspiring Future Engineers

Robotic fish have become an important avenue for recruitment and K-12 outreach. Through collaboration with Drew Kim, assistant to the dean for recruitment and K-12 outreach, Xiaobo Tan's research group developed a robotic fish–based educational kit for middle and high school students to inspire their interest in science and engineering. With the kit students can learn how to build a robotic fish and in the process gain a basic knowledge of robotics, artificial muscles, and circuits. The kit is used in local schools, and student teams came to the fall 2007 and spring 2008 College of Engineering Design Days to present and race their robotic fish prototypes.

With a proven track record in outreach, Tan, along with Kim and other engineering faculty, is launching a teacher training initiative by engaging middle and high school science teachers in university lab research on bio-inspired technology and systems.

The robotic fish were attention getters during Michigan State's Grandparents University.

from the Chair

TIMOTHY GROTJOHN

Greetings to alumni and friends of the MSU Department of Electrical and Computer Engineering. This newsletter shares several highlights of our undergraduate, graduate, and research programs.

Our department offers BS degrees in electrical engineering and computer engineering to over 500 undergraduate students. The computer engineering degree is offered jointly with the Department of Computer Science and Engineering. Our students acquire a solid foundation in electrical and computer engineering theory, gain experience in critical thinking, and explore innovative ways to address advanced engineering problems. Design and hands-on labs and courses are offered in all years of the curriculum. This starts in the freshman year when students take the cornerstone engineering design course their first semester and concludes with the senior design challenge in the last year that engages students in multidisciplinary teaming and open-ended problem solving. As a result, our students learn how to work with people from other science or engineering fields and are prepared for true-to-life work environments. Additionally, over the past few years the department has put a strong emphasis on all the undergraduate students having opportunities for engineering experience outside the classroom by participating in cooperative education, internships, study abroad, and/or undergraduate research. In a recent survey of graduating seniors, more than 90 percent have had some type of engineering experience outside the classroom.

The ECE graduate program is built on the quality of our 40 faculty and their research. This year 190 students are enrolled in our MS and PhD graduate programs. Our research activities have witnessed strong growth in recent years with annual research expenditures now over $10 million. Our faculty members are leaders in their chosen fields and are highly respected by their peers. The ECE faculty are continually investigating new areas of research. However, we retain our focus on computer engineering (computer architecture, computer networks, and VLSI/microelectronics), electro sciences (electromagnetics, electronic materials and devices, and nondestructive evaluation), and systems (biomedical engineering, control and robotics, power electronics and systems, and signal processing and communications). During this academic year we have four new faculty members joining our department in the areas of electrical power systems, Terahertz technology, nanomanipulation, and MEMS (micro-electro-mechanical systems.)

I want to invite you to stay in touch with us. These are exciting times, and we want to share our enthusiasm with you as we continue to grow our research-centered, student-oriented department.

Making Waves (continued from page 1)

electroactive polymer hairs as artificial lateral lines for flow sensing," says Tan. This should give the robotic fish better balance. In addition, Tan and his research team want to develop fins capable of complex three-dimensional movements, as real fish fins are. The research is expected to advance the performance of robotic fish toward that of their biological counterparts. In the process, the research will potentially provide a way to investigate the locomotor and sensory mechanisms of real fish.

Tan wants to develop teacher training by engaging middle and high school science teachers in university lab research. John Thon, a Holt Junior High School teacher (wearing black shirt), works with Tan (top of photo), PhD student Dawn Hedgepeth, and Mart Anton, a post doctoral researcher (foreground).

Ultimately, Tan wants to be able to launch schools of the robotic fish in ponds, lakes, or an ocean and use them for tasks such as detecting pollution and harmful algal blooms, monitoring aqua-farms, and safeguarding drinking water reservoirs. That challenge has graduate students enthused. "There are many serious research issues, especially related to energy efficiency and energy harvesting," says Tan.

– Jane L. DePriest

Getting Legislative Attention

Robotic fish are definitely attention getters. That's part of the reason MSU selected Xiaobo Tan to be part of the 14th Annual Coalition for National Science Funding (CNSF) Exhibition and Reception in Washington D. C. this past summer. MSU is part of the CNSF, an alliance of more than 100 institutions and professional societies that supports the goal of increasing the national investment in the NSF's research and education programs.

During the exhibit, researchers had an opportunity to meet legislators and explain their research and the importance of scientific funding. Tan and ECE PhD student, Dawn Hedgepeth, presented a poster, "Electroactive Polymers as Artificial Muscles and Sensors; Investigation from a Systems Perspective," that described Tan's NSF CAREER project and its potential for societal, educational, and outreach impacts. The highlight was a live demonstration of artificial muscle-enabled robotic fish, which made their conversations with congressmen and their staffers much easier.

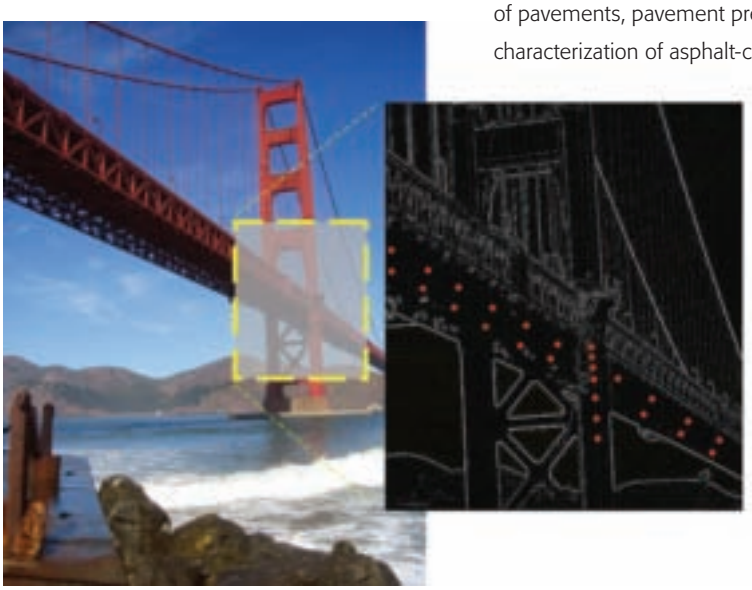
Dawn Hedgepeth (left), ECE PHD student, and Xiaobo Tan (center) visit with Arden Bement, director of the National Science Foundation during the CNSF Exhibit on Capitol Hill.

Silicon Meets Concrete: Self-Powered Sensor Brings New Technology to Highway Monitoring

New technology is having an impact on everyone's life, and a sensor being developed by a multi-disciplinary research team at the MSU College of Engineering may someday put an end to potholes and ruts in Michigan highways and in pavements throughout the country.

Shantanu Chakrabartty, ECE assistant professor; Nizar Lajnef, Civil and Environmental Engineering (CEE) assistant professor; and Karim Chatti, CEE associate professor, recently received funding from the Federal Highway Administration (FHWA) to develop a low-cost self-powered, wireless sensor that can be economically attached to pavement structures, either during construction or at any time during routine maintenance operations. The sensor will harvest power from the traffic loads to compute and store usage statistics that enable structural health monitoring. This sensor can then communicate the data collected directly to a service vehicle. The ultimate goal is to be able to predict damage in pavement before it appears, which would be a significant improvement to the field of pavement monitoring and management.

Chakrabartty first got involved as a co-adviser to Lajnef on his PhD work. (Niell Elvin, a former CEE faculty member, was Lajnef's other adviser. Elvin is now at City College in New York City.)



This drawing shows how a sensor network might be mounted on a bridge.

"State-of-the-art sensors today need batteries. Our sensor can harvest power from the movement of traffic on the highway. This is called power harvesting," says Chakrabartty, who specializes in research on low-power electronics. "Niell came to my office one day with this concept, but civil engineers think in terms of big, big objects. This sensor needed to be small." The current sensor is smaller than Abraham Lincoln's face on a penny.

Shantanu Chakrabartty

Vibration and mechanical movement generate the power for the sensor. It is self-sustaining, with no wires or batteries. "There has been significant research activity in wireless sensors to monitor industrial processes and environmental conditions," says Lajnef. "However, all of the commercially viable sensors developed to date require either solar or battery power, both of which are impractical for monitoring pavement structures, where periodic replacement of batteries or the expense of solar power technology would be cost-prohibitive and in some cases impractical."

Chatti specializes in pavement response and performance modeling, as well as the dynamics of pavements, pavement preservation, and characterization of asphalt-concrete mixtures, so he is a natural partner for the FHWA project. With a working prototype in hand, researchers can run tests in Chatti's lab. These sensors need to be embedded in the pavement structure when it is being built, i.e. during construction. "So there are questions of durability," says Chatti. "Will it withstand the high temperatures of asphalt when it is poured and the stress of heavy equipment rolling out the asphalt, and eventually the stress of constant traffic?"

The researchers looked at various power sources for the system – solar, temperature gradients, piezoelectric materials, and others. They had to optimize the amount of harvested energy with respect to cost and system size, so it could be easily embedded with no major effect on the host structure. The current sensor consumes 800 nanowatts of power. For the next version, they would like to lower the power consumption to 20 nanowatts. "The lower power output enables us to make a smaller sensor that is more sensitive and causes less disruption," says Chakrabartty.

The size of the sensor is especially important in medical applications, which is one of several potential uses for the sensor besides pavement applications. This application includes hip and knee implants where the sensor would monitor fatigue. It may also have an application in buildings, where the sensor would record stress data.

The low-cost, self-powered sensor is smaller than Abraham Lincoln's face on a penny.

Another application idea is to use the sensor in wind turbines. The sensor would monitor and record usage data so that turbines could be replaced before they fail, which would be less costly and would prevent unexpected catastrophic failures. Lajnef also hopes that eventually the sensors could help with better turbine performance. Lajnef and Chakrabartty have several patents pending on the sensor.

"This sensor is a decade ahead of competing sensors," says Chatti. "There is serious research going on in the field of self-powering, and MSU is at the forefront of it. We are ahead of what researchers at other universities are doing. This is a significant achievement."

– Jane L. DePriest

Faculty and Staff Networks

New Faculty

Joydeep Mitra has joined the department as an associate professor. Prior to this appointment he held academic positions at New Mexico State University and North Dakota State University, and was a senior consulting engineer with LCG Consulting, Los Altos, Calif. He earned his PhD in electrical engineering from Texas A&M University and his bachelor's degree, also in electrical engineering, from the Indian Institute of Technology, Kharagpur. His research interests include power system reliability and security, and distributed and renewable energy resource planning. He has received research support from electric utilities, Sandia National Laboratories, the Department of Energy, and the National Science Foundation, including an NSF CAREER Award. He is a senior member of the IEEE and actively participates in Power and Energy Society, the Industrial Applications Society, and the Standards Association.

Boutheina Kzadri Tlili has joined the department as an associate professor and director of the computer engineering program at MSU-Dubai. Tlili earned her PhD ('94) in electrical engineering from Michigan State University. Prior to joining the ECE faculty, she was an associate professor and program coordinator of the electrical and computer engineering program at the American University in Dubai from 2004-2008. Her research interests include antenna analysis and design, electromagnetic theory, field propagation in complex media, and microwave electronics. Tlili is an IEEE senior member and IEEE Women in Engineering chair for the United Arab Emirates (UAE) section.

MANCEF Board of Directors

Dean Aslam, associate professor, was elected associate vice president, Americas, of the Micro and Nanotechnology Commercialization Education Foundation (MANCEF) Board of Directors in August. MANCEF's mission is to connect the global community engaged in the commercialization of emerging micro and nanotechnologies. MANCEF has a presence in the Americas, Africa, Europe, and Asia. The organization holds a conference every year in a different part of the world.

For the past 10 years, Aslam has been applying LEGO-based objects to complicated engineering tactics as part of his university research and as a method of outreach. Aslam and his research assistants already have built a LEGO piano that plays different sounds depending on the charge of the object that strikes the key, and an MSU Smart Robot LEGO car that runs on a track, among other projects. The outreach component of the research involves regularly working with third-graders at Woodcreek Elementary School in Lansing to teach them electrical engineering concepts.

AAAS Lifetime Mentor Award

Percy Pierre, MSU vice president and ECE professor emeritus, has received the 2008 Lifetime Mentor Award from the American Association for the Advancement of Science (AAAS). The award honors individuals who demonstrate extraordinary leadership to increase the participation of underrepresented groups in science and engineering fields and careers; and who have mentored and guided significant numbers of students from underrepresented groups to the completion of doctoral studies. Pierre was honored for his extraordinary dedication to increasing the number of African-American and Hispanic American PhDs in engineering.

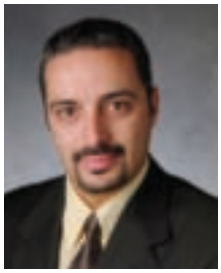
He came to MSU in 1998 and started the Sloan Engineering Program in the College of Engineering. This program supports the recruitment and retention of minority doctoral students. Through this program alone, Pierre has mentored 27 doctoral graduates in engineering.

"Many thousands of students have benefitted from Dr. Pierre's tireless work," says Satish Udpa, dean of the College of Engineering. "His commitment to providing these types of opportunities to underrepresented groups is unmatched. I know of no one who is more deserving of this award."

The award will be presented to Pierre in February at the AAAS annual meeting in Chicago.

Research Funding

Subir Biswas, associate professor, in collaboration with the University of Michigan, has received a grant from the Information Technology and Infrastructure Systems program at the National Science Foundation for his project: "Protocols for Wireless Networking and Multi-Application Data Handling for Freeway Traffic Safety Applications." The grant will support research on vehicular networks and distributed vehicular grid computing for traffic safety applications.



Karim Oweiss, assistant professor, along with researchers in his lab, was recently awarded a new National Institutes of Health R01 grant to design and build a fully implantable, wireless, and distributed interface to the cerbral cortex.

The grant, funded by the National Institute of Neurological Disorders and Stroke under the Neuroprosthesis Program, is for the purpose of building the first-ever large-scale interface to the cortex of awake, freely behaving subjects to monitor brain activity at exceedingly high temporal and spatial resolutions. The project will help to characterize the activity of individual neurons in people carrying out normal daily life functions. The impact of this technology will ultimately be to enable understanding of many aspects of how the human brain works as well as understanding of many neurological diseases and disorders.

Ning Xi, professor; Percy Pierre, professor emeritus; Matt Mutka, CSE professor and department chair; and Patricia Farrel, specialist in MSU's Department of Educational Administration, in collaboration with Howard University, have been awarded a new grant from the National Science Foundation. The project is entitled "CI-TEAM Demonstration Project for Real-Time Interactive and Collaborative Cyberinfrastructure for Teaching and Training of Hands-On Nanotechnology." Using advances in Internet and robotics technology, this project will enable new and innovative methods of teaching and training university students and professionals involved with nanotechnology. People at different geographical locations may work or learn together to control a remote nano-manufacturing system or scientific instruments, based on haptic feedback in addition to video and audio.

Consumers Energy Foundation Grant Supports Teaching and Research

The Consumers Energy Foundation granted the College of Engineering $150,000 for development of a flexible power station to enable the Department of Electrical and Computer Engineering to better train students and to expand the research capacity of its faculty to help meet the nation's energy needs.

Fang Z. Peng, professor and director of the ZELRI-MSU Research Center and head of the power station project, explains that the funding from the Consumers Energy Foundation will be used to build Phase I of a low-voltage (from 120-volt single-phase to 480-volt three-phase) power station, which will provide a platform for education and study related to how power quality affects loads in residential and commercial buildings (120 to 480 volts) and how those loads affect the power grid. The power station will also lend itself to research into plug-in hybrid electric vehicles and renewable energy sources—specifically, photovoltaic power for residential use and grid interconnection.

About 20 students, mostly at the graduate level, will utilize the flexible power station. "This will allow us to train our students in the latest technology—such as renewable energy sources, utility interface technology, and power quality assurance issues," says Peng. "We will be able to increase their learning in key areas like power system design and analysis, power electronics, electric machines, and emerging energy conversion/utilization technology. This will better prepare them for careers in the energy and electric power industries."

The ECE department is a leader in the areas of power systems, power electronics, and electrical machines, and they graduate many highly trained students each year. All of Peng's graduate students have gone on to work in an energy-related industry.

Faculty research will also benefit from this new project. The flexible power station will provide a platform for research and evaluation of how new technology, such as the plug-in hybrid electric vehicle (HEV), affects the residential power load and the power grid; extend the current research on power electronics for the plug-in HEV and utility interface from component level to upper-system level; and facilitate collaborative research among faculty members in energy-related areas.

Photo by Harley J. Seeley/MSU University Relations

Professor Fang Z. Peng (left), director of the ZELRI-MSU Research Center and head of the power station project funded in part by the Consumers Energy Foundation, discusses his work with Satish Udpa, dean of the College of Engineering, during an open house at the ZELRI Center.

Alumni Networks

2008 John D. Ryder Alumni Award

Robert W. Leland (BS '85) received the John D. Ryder Electrical and Computer Engineering Alumni Award at a College of Engineering banquet in May 2008. Established in 2004, this award commemorates the outstanding professional contributions of John D. Ryder, former dean of the College of Engineering and a professor in the department. The award is given on the basis of contributions that further the mission of the department.

Leland has spent his career to date working with Sandia National Laboratories. Currently taking a break from directing the lab's operational information technology (IT) effort, he is assigned to Sandia's executive office leading the development of a national engagement strategy for cyber security. This addresses the prospect that cyber attacks may rise to the level of "weapons of mass destruction" in the degree of disruption they cause.

Leland was previously a member of Sandia's Advanced Concepts Group studying long-term national security issues and was appointed by President Clinton in 1995 to serve as one of 14 White House fellows in the U.S. government's premier leadership development program.

He first came to MSU under the Alumni Distinguished Scholarship program and was a member of the Honors College. After earning a BS in electrical engineering with a minor in mechanical engineering, he was named a Rhodes Scholar and studied applied mathematics and computer science at Oxford University, completing a PhD in parallel computing in 1989. He was able to continue his studies at Oxford as a National Science Foundation graduate fellow.

After Oxford, Leland joined the Parallel Computing Sciences Department at Sandia National Laboratories, working in parallel algorithm development and applied graph theory. He co-authored Chaco, a widely used graph partitioning and sequencing tool kit. Chaco was a finalist in the Wilkinson competition for the best numerical software written worldwide over a four-year period.

In 1995, while a White House fellow, Leland advised the Deputy Secretary and Secretary of the Treasury on technology modernization at the IRS. Upon returning to Sandia in 1996, he led the Parallel Computing Sciences Department and an R&D group developing algorithmic technology and software tools in support of the laboratory's scientific computing efforts. He subsequently led the computer and software systems group, which developed Red Storm, one of the world's most capable supercomputers, in partnership with Cray Inc.

In 2002 he accepted the position of director of the Computing and Networking Services Center at Sandia, a 650-person organization providing IT infrastructure and services to the laboratory. The center is responsible for the operation of world-class super-computing platforms, enterprise computing platforms, voice and data networks, desktop support, and cyber security for a 10,000-person laboratory.

Leland met his wife, Robyn, through a mutual friend at Sandia, and they now have two young daughters – Lauren and Halie. The Lelands all enjoy living in the great outdoors in New Mexico, especially swimming in the summer and skiing in the winter. Even Halie, who was only 2 at the time, was on the slopes at Taos last winter.

Special Extreme Makeover: Home Edition Award

Outside the normal project team structure, a group of ECE seniors enrolled in ECE 480 participated in the *Extreme Makeover: Home Edition* project conducted in Holt, Mich., and televised in November 2008.

ABC's *Extreme Makeover: Home Edition* came to mid-Michigan to build a new home for Arlene Nickless and her three sons. Engineering faculty and students helped design an electronic lighting display for the room of Aaron Nickless, the oldest son, who is interested in electrical engineering. They also assisted in making other electronics projects in the home actually work!

Team members, who received special recognition at the fall 2008 College of Engineering Design Days, were George Ballios, Michael Dow, Ben Kershner, and Nicholas Vogtmann. They were assisted by ECE professors Tim Hogan and Leo Kempel.

Photo by Laura Seeley

At right, Paige Hemmis, one of the designers on *Extreme Makeover: Home Edition*, works with Ben Kershner on the room for Aaron Nickless. Above, the student team that helped with the Extreme Makeover included (from left) Nicholas Vogtmann, Ben Kershner, George Ballios, and Michael Dow.

Student Networks

ECE Students Show Off Skills at Design Days

The College of Engineering Design Days showcase the accomplishments of the next generation of MSU engineering designers, innovators, and entrepreneurs. Design Days for the fall 2008 semester were held December 4 and 5 at the MSU Union Building. In addition to the ECE department, students from the Department of Civil and Environmental Engineering, the Department of Computer Science and Engineering, and the Department of Mechanical Engineering participated in the event.

Headliners at Design Days are the graduating seniors as they present their capstone design projects, which provide unique opportunities for students and faculty to collaborate with more than 25 industrial sponsors, through posters and oral presentations. "The seniors who are graduating, get to show off things that they would not have believed they could do when they came in as freshmen," says Erik Goodman, ECE professor and the instructor for the ECE senior capstone design course. "The atmosphere is very electric."

While all who completed projects and made presentations are "winners," there are numerous awards. For fall 2008 the top ECE winners are below:

Prism VentureWorks Prizes: These prizes are awarded each semester to the most outstanding teams in the ECE Senior Capstone Design Course, as judged by a panel of engineers from industry. A team with members from both ECE and another engineering major (mechanical engineering, for example) is also eligible, if the team's project is administered through ECE 480. The prizes are sponsored by Prism VentureWorks, a Boston-based venture capital firm, and William Seifert, an ECE alumnus, who is a partner in that firm.

1st Place (split $1,500): Inexpensive Radar for Through-Object Viewing, sponsored by the Naval Research Lab. Faculty facilitator: Terence Brown. Team members: Ali Agel, Michael Volz, Garrett Warnell, Scott Warren, and Michael Weingarten.

2nd Place (split $1,000): Quasi-Motion Ship Simulator – joint project with ECE and mechanical engineering (ME), sponsored by PI engineering. Faculty facilitators: Cevat Gokcek and George Zhu. Team members: Ryan Boak (ME), Doug Gobeski (ME), Justin King (ECE), Michael Priebe (ME), Daniel Raphael (ME), Mark Rogers (ECE), Rebecca Wahmhoff (ECE), and Bryan Witherspoon (ECE).

3rd Place (split $500): Solar-Powered Multi-User Internet Access for Schools in Developing Countries, sponsored by Lenovo. Faculty facilitators: Kurt DeMaagd and Jian Ren. Team members: Benjamin Kershner, Jakub Mazur, Eric Tarkleson, and Joshua Wong.

Professor's Choice Award ($1,000): This award is given each semester by the faculty member teaching ECE 480, Senior Capstone Design, to the team judged by the instructor to have done the most to achieve the objectives of the course and sponsor, particularly taking into account the varying levels of challenge of the projects. Judging is based on reading of the teams' final reports, examination of their posters/prototypes, and communication with their faculty facilitators.

Automated Trace Gas Trapping System, sponsored by Biogeochemistry Environmental Research Initiative – a joint project with ECE and mechanical engineering (ME). Faculty facilitators: John Deller and Ranjan Mukherjee. Team members: Daniel Cashen (ECE), Alex Esbrook (ECE), Chris Gliniecki (ECE), Adam Grisdale (ME), Thomas Hancasky (ECE), Alex Kerstien (ME), and Josh Kowalski (ME).

Winners of the first place Prism Award included (from left) Michael Weingarten, Ali Aqel, Garrett Warnell, Scott Warren, and Michael Volz.

Winners of the Professor's Choice Award included (from left) Alex Esbrook, Thomas Hancasky, Daniel Cashen, Adam Grisdale, Josh Kowalski, Christ Gliniecki, Alex Kerstien, and Professor Erik Goodman.

Winners of the second place Prism Award included (top row, from left): Bryan Witherspoon, Michael Priebe, Rebecca Wahmhoff, and Mark Rogers; (bottom row, from left) Ryan Boak, Doug Gobeski, Daniel Raphael, and Justin King.

Winners of the third place Prism Award included (from left) Ben Kershner, Eric Tarkleson, Jakub Mazur, and Josh Wong.

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Fall 2008 Design Days

Michael Volz (left) answers questions from "reporters" from Lansing's Woodcreek Magnet School who interviewed MSU students at Design Days as a school assignment.

Jeff Calderas with General Motors (center) discusses an automated material cutter with Kyle Coveart (left) and Ryan Everaert.